

DEMOGRAPHIC MONITORING OF TWO STANLEY BASIN ENDEMICS,  
*DRABA TRICHOCARPA* AND *ERIOGONUM MELEDONUM*.  
III. THIRD-YEAR RESULTS

by

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## ABSTRACT

*Draba trichocarpa* (Stanley whitlow-grass) and *Eriogonum meledonum* (guardian buckwheat) are endemic to the Stanley Basin, Idaho, where they occur in small populations on restricted habitats. *D. trichocarpa* is restricted to a series of granite outcrops surrounding the floor of the Stanley Basin. Less than 7,000 individuals are known to occur in 14 populations, occupying less than 100 acres. *E. meledonum* occurs in similar habitats, where only ten populations are known, containing less than 4,500 individuals and comprising less than 45 acres. The two species are sympatric at seven sites.

Thorough status surveys were conducted for these species in 1987 and 1988 by the Idaho Conservation Data Center. While no short-term, extrinsic threats were observed, population vulnerability remained a concern because of low numbers and very restricted distribution. *Draba trichocarpa* is currently a category 2 candidate for federal listing. *Eriogonum meledonum* has only recently been described, and has been recommended for inclusion on the candidate list in category 1. It has been recommended that the Sawtooth National Forest develop a Habitat Conservation Assessment for both species.

A demographic monitoring program was deemed necessary to provide pertinent population data for habitat management plan development. During 1990, six permanent monitoring transects were established in *E. meledonum* and *D. trichocarpa* populations on Forest Service land in the Stanley Basin. The transects were read in early summer in 1990, 1991, and 1992.

Results indicate that the demography of both *D. trichocarpa* and *E. meledonum* are similar. Of the three life stages for which we kept track, seedlings, nonreproductive and reproductive individuals, the later two stages are relatively stable, represented by many hundreds of individuals in the six transects. The seedling stage, however, is a different story. We recorded only four *Eriogonum* and 19 *Draba* seedlings in the three year study, and the seedling mortality rate was high for both species. The transition matrix population models constructed for each species both predicted a decline in the populations over a five year period.

Our data suggest that for both species, once a plant reaches maturity it is rather long-lived and that the low seedling recruitment is the major bottleneck contributing to this predicted decline. We recommend that two major data gaps need to be filled before future population fluctuations, and risk of extinction or decline can be more accurately modelled: (1) a longer-term data set is needed on seedling survival rates that will encompass a greater amount of annual variability; and (2) a seed stage, based on direct observation instead of inference, needs to be built into the model.

## ACKNOWLEDGEMENTS

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## TABLE OF CONTENTS

ABSTRACT .....	i
ACKNOWLEDGEMENTS .....	i
TABLE OF CONTENTS .....	ii
LIST OF FIGURES .....	iii
LIST OF TABLES .....	iii
LIST OF APPENDICES .....	iv
INTRODUCTION .....	1
STUDY AREA .....	2
STUDY SITES .....	4
GENERAL METHODS	
Field Sampling .....	7
Population modelling .....	8
RESULTS	
<i>DRABA TRICHOCARPA</i>	
Natural History and Morphology .....	9
Field Methods .....	9
Seeds .....	10
Population Structure and Averages .....	10
Population Model .....	12
 <i>ERIOGONUM MELEDONUM</i>	
Natural History and Morphology .....	16
Field Methods .....	16
Seeds .....	17
Population Structure and Averages .....	17
Population Model .....	19
CONCLUSIONS AND RECOMMENDATIONS .....	23
REFERENCES .....	25

## LIST OF FIGURES

Figure 1.	Distribution of <i>Draba trichocarpa</i> and <i>Eriogonum meledonum</i> and location of study sites. . . . .	3
Figure 2.	Diagrammatic representation of the belt transect used in the Stanley Basin demographic monitoring study. . . . .	8
Figure 3.	The life cycle of <i>Draba trichocarpa</i> . Reproductive output and transfer rates were calculated using 1990 to 1992 data. . . . .	13
Figure 4.	Projection matrix corresponding to the life cycle of <i>Draba trichocarpa</i> presented in Figure 3. . . . .	14
Figure 5.	Projected decline of <i>Draba trichocarpa</i> at five populations over a five year interval. Population size includes the total number of plants in the five populations, including seedlings, nonreproductive, and reproductive. . . . .	15
Figure 6.	The life cycle of <i>Eriogonum meledonum</i> . Reproductive output and transfer rates were calculated using 1990 to 1992 data. . . . .	20
Figure 7.	Projection matrix corresponding to the life cycle of <i>Eriogonum meledonum</i> presented in Figure 6. . . . .	21
Figure 8.	Projected decline of <i>Eriogonum meledonum</i> at five populations over a five year interval. Population size includes the total number of plants in the five populations, including seedlings, nonreproductive, and reproductive. . . . .	22

## LIST OF TABLES

Table 1.	Demographic monitoring transects for <i>Draba trichocarpa</i> and <i>Eriogonum meledonum</i> established in the Stanley Basin, July 1990. . . . .	4
Table 2.	1990 to 1992 population density and fecundity data for <i>Draba trichocarpa</i> in five long-term monitoring transects established in the Stanley Basin. . . . .	11
Table 3.	1990 to 1992 population density and fecundity data for <i>Eriogonum meledonum</i> in five long-term monitoring transects established in the Stanley Basin. . . . .	18

## LIST OF APPENDICES

Appendix 1. 1992 Lotus 1-2-3 data files for the six Stanley Basin transects.

Appendix 2. Life stage transition data, 1990 to 1992, for *Draba trichocarpa*.

Appendix 3. Life stage transition data, 1990 to 1992, for *Eriogonum meledonum*.

## INTRODUCTION

The primary goal of most rare plant management is to maintain viable populations of the rare species, yet the management of natural communities containing rare plant populations poses several basic questions for land managers: Are current land management practices adequate to maintain the community or the species? What effect will specific management activities have on the rare plant on a site? What is necessary to ensure the survival of a species? Most of these questions cannot be answered by casual observation and, therefore, some level of monitoring is needed (Sutter 1986). In its simplest form, monitoring may entail periodic estimates of population size. This level of information, however, may not provide enough information to make management decisions and a deeper understanding of population dynamics is needed (Lesica 1987).

Environmental, demographic, and genetic stochasticity are major causes of extinction in habitats specifically managed to protect rare plant populations. Of these three, managers can use demographic information to predict plant population dynamics without necessarily knowing or conducting expensive studies on the environmental and genetic mechanisms (Menges 1986). In fact, demographic factors affecting population dynamics are considered of more immediate concern than population genetics in determining minimum viable populations (Lande 1988).

Demography is the study of population changes and their causes through the life cycle of a plant. Population attributes such as birth and death rates, growth, size, density and distribution are some of the characteristics measured. Demographic studies of plants have indicated that each population possesses attributes that determine local abundance and/or persistence through time. A thorough analysis of these attributes is of primary importance in the management of rare and endangered plant populations, simply because abundance and persistence are at the center of all conservation efforts (Pavlik and Barbour 1988). Demographic monitoring studies can help determine the factors that control the abundance and distribution of a species and can generate data useful in predicting the future size and age structure of a population.

Although more costly than simple inventories, demographic studies and related monitoring methods provide managers with a vastly superior understanding of a species life history and greater ability to predict population trends (Larkin and Salzar 1992). In conservation management for instance, it is necessary to determine the greatest threats to a species' survival. Demographic stochasticity causes population fluctuations and is an important threat to extinction when populations are very small. Since most rare plants occur in small populations, we should assume that demographic variation is a formidable threat (Larkin and Salzar 1992).

Demographic monitoring of rare species has become increasingly important as the efforts of natural resource agencies has evolved from an emphasis on the inventory and status determination of rare species to active protection efforts. Such is the case of two Stanley Basin endemics, *Draba trichocarpa* (Stanley whitlow-grass) and *Eriogonum meledonum* (guardian buckwheat). Both species have recently been described (Rollins 1984; Reveal 1989), although the existence of guardian buckwheat has been known since the early 1970's. Thorough status surveys were conducted in 1987 and 1988 by the Conservation Data Center (Caicco 1988; Moseley 1988). We found that both species occur in small populations on restricted habitats in the Stanley Basin. While no short-term, extrinsic threats were observed, population vulnerability remained a concern because of low numbers and very restricted distribution.

*Draba trichocarpa* is currently a category 2 candidate for federal listing (U.S. Fish and Wildlife Service

1990), but is recommended for category 1 status when the next Federal Register list is published (Idaho Native Plant Society 1993). Now that it has formally been described, *Eriogonum meledonum* has been recommended for inclusion on the candidate list in category 1 (Idaho Native Plant Society 1993). Both species are Forest Service Region 4 Sensitive Species (Spahr *et al.* 1991). Caicco (1988) and Moseley (1988) recommended that the Sawtooth National Forest develop a Habitat Conservation Assessment for both species.

In 1990, through the Forest Service's challenge cost share program, the Sawtooth National Forest and the Idaho Department of Fish and Game's Conservation Data Center, began a demographic monitoring project on the two species. This cooperative project continued for three years until 1992. The results of the first and second year of the project are reported in Moseley and Mancuso (1990; 1992). Specific objectives of the this study include:

1. Design and implement a demographic monitoring program for the two species;
2. Construct stage-structured demographic models of population dynamics for use in development in a Habitat Conservation Assessment;
3. Identify further research needed to fully understand the mechanisms behind the dynamics of these plant populations.

## STUDY AREA

The Stanley Basin is a large, relatively high-elevation intermontane basin in the upper Salmon River drainage. It is surrounded by mountains on all sides; the Sawtooth Range to the southwest, White Cloud Peaks to the northeast, and the Salmon River Mountains to the north. The basin is largely dominated by sagebrush-steppe vegetation, with isolated stands of Douglas-fir and lodgepole pine on northerly slopes. Coniferous forests dominate the higher slopes surrounding the basin. The Salmon River traverses the basin from south to north and exits through a narrow canyon at the northern end. This constriction in the valley bottom, in combination with cold air drainage from the surrounding peaks, creates an intense cold air sink in the basin throughout the year. The mean annual temperature at the Stanley weather station, elevation 6,200 feet, is 36.4 °F, and the mean annual precipitation is 10.2 inches (Johnson 1981).

*Draba trichocarpa* and *Eriogonum meledonum* are virtually sympatric on exposed outcrops and scree slopes on the periphery of the basin (Figure 1). These convex surfaces occur on upper slopes and ridges underlain by grandiorite or granite. Both species are restricted to bedrock or residual scree and are never found on similar-appearing glacial drift or alluvial substrates.

*Artemisia arbuscula* ssp. *thermopola* is the most prominent species in this habitat, although vegetative cover is low, consisting of widely scattered plants on the rock and scree surfaces. At some sites, this community corresponds to the *Artemisia arbuscula* ssp. *thermopola*/*Festuca idahoensis* habitat type (Hironaka *et al.* 1983). The communities at other sites have not been described. Associated species

Figure 1. Distribution of *Draba trichocarpa* and *Eriogonum meledonum* and location of study sites (portion of 1957 Challis 1:250,000 quadrangle). See Moseley and Mancuso (1990) for maps containing more precise locations of the six transects.

include *Eriogonum flavum*, *E. ovalifolium*, *E. umbellatum*, *Sedum lanceolatum*, *Poa secunda*, *Erigeron linearis*, *Erigeron compositus*, *Sitanion hystrix*, *Lesquerella occidentalis*, *Antennaria microphylla*, and *Polemonium viscosum*. Elsewhere in Idaho, *Polemonium viscosum* occurs exclusively in the alpine zone, possibly indicating the relatively cold temperatures that exist in these habitats throughout the year. Adjacent vegetation includes the *Artemisia tridentata* ssp. *vaseyana*/*Festuca idahoensis* (Hironaka *et al.* 1983), *Pseudotsuga menziesii*/*Calamagrostis rubescens*, and *Pinus contorta*/*Festuca idahoensis* (Steele *et al.* 1981) habitat types.

## STUDY SITES

We chose six sites to place permanent monitoring transects in 1990 (Figure 1). As summarized in Table 1, three transects had both species, two had only *Draba trichocarpa* and one had only *Eriogonum meledonum*.

Table 1. Demographic monitoring transects for *Draba trichocarpa* and *Eriogonum meledonum* established in the Stanley Basin, July 1990.

Tran. #	Site Name	Species (CDC occurrence #)	Length (m)
1.	Stanley Creek	<i>Draba trichocarpa</i> (001) <i>Eriogonum meledonum</i> (002)	25
2.	Sportsmen's Access #3	<i>Eriogonum meledonum</i> (005)	50
3.	Middle Stanley	<i>Draba trichocarpa</i> (004)	25
4.	Mile 377.5 Gulch	<i>Draba trichocarpa</i> (007)	25
5.	Stanley #4	<i>Draba trichocarpa</i> (003) <i>Eriogonum meledonum</i> (008)	15 in 1990 7 in 1991 & 1992
6.	Arrow A Ranch North	<i>Draba trichocarpa</i> (009) <i>Eriogonum meledonum</i> (006)	25

### Stanley Creek - Transect 1

#### Location :

**Disturbance** Cattle grazing occurs in surrounding meadows, where it is locally heavy. Cattle trail across the population to short-cut getting from the side draw (W of population) into main Stanley Creek meadows and visa versa. Not much actual grazing takes place on the site due to the sparse vegetation, although some *Festuca idahoensis* bunches were munched to the crown along the transect. ORV (motorbike) tracks have been seen cutting through the population in the past.

**Habitat** The community is undescribed in the literature, but comes closest to the *Artemisia arbuscula* ssp. *thermopola*/*Festuca idahoensis* habitat type. There is much more *Sitanion hystrix* than *F. idahoensis*, however. The surrounding vegetations are the *Artemisia tridentata* ssp. *vaseyana*/*F. idahoensis* and *Pseudotsuga menziesii*/*Calamagrostis rubescens* habitat types. The *Artemisia cana*/*Deschampsia cespitosa* riparian community dominates surrounding lowland

meadows.

### **Sportsmen's Access #3 - Transect 2**

#### Location :

Disturbance The near-by 2-track jeep trail does not enter the population. Some old cow pies (several years old) occur along the transect. An old boundary fence cuts through the population several meters below the end of the transect.

Habitat This subpopulation occurs in a relatively small microsite dominated by *Phlox austromontana* and *Sitanion hystrix* with high prominence of *Astragalus whitneyi*, *Poa secunda*, and *Erigeron compositus*. Surrounding slopes are mostly *Artemisia tridentata* ssp. *vaseyana*/*F. idahoensis* with pockets of *Pseudotsuga menziesii*/*Calamagrostis rubescens* on north slopes.

### **Middle Stanley - Transect 3**

#### Location :

Disturbance Virtually none. Highway construction may have disturbed some habitat on lower slope, but they did not cut into slope much, just filled in the river(!). Effluent from Stanley sewage ponds was pumped up to ridge, several hundred meters above the site when their system broke temporarily in 1990. No impact to population was observed.

Habitat The community in which *Draba trichocarpa* occurs is the *Artemisia arbuscula* ssp. *thermopola*/*Festuca idahoensis* habitat type, with bedrock very close to the surface. Above this is the *Artemisia tridentata* ssp. *vaseyana*/*F. idahoensis* habitat type, occurring on old, perched river gravels.

### **Mile 377.5 Gulch - Transect 4**

#### Location

Disturbance Virtually none. No evidence of cattle grazing. It appears that elk winter on ridge, with some spring use also possible.

Habitat The transect runs through the windswept portion of the *Artemisia tridentata* ssp. *vaseyana*/*F. idahoensis* habitat type. *Artemisia tridentata* cover is low along the transect. A *Purshia tridentata* community occurs on adjacent slopes.

### **Stanley #4 - Transect 5**

#### Location

Disturbance Dirt track on ridgeline for motorbikes, mountain bikes, and hikers bisects the population, but does not come near the transect. No evidence of cattle grazing. The USFS boundary wand was broken off at the ground in 1991 and the 0.0 stake of the transect had also been removed that year. This combined to make precise location of the transect difficult.

Habitat Exposed *Artemisia arbuscula* ssp. *thermopola* site with little *Festuca idahoensis* present. *Geum triflorum* common in stand; the alpine species, *Polemonium viscosum* and *Calamagrostis purpurascens*, are also prominent. Deeper soil sites in vicinity are *Artemisia tridentata* ssp. *vaseyana*/*Festuca idahoensis* with *Pinus contorta* and *Pseudotsuga menziesii* on northerly slopes.

### **Arrow A Ranch North - Transect 6**

Location NOTE: permission should be obtained from the owner of the Arrow A Ranch for access to the transect.

Disturbance Elk winter on slope, although not too heavy at elevation of transect. Animal trails (probably mostly elk, but also horses and cattle) run down the ridge through the transect. *Draba trichocarpa* does not appear to be abundant near erosion channels/animal trails.

Habitat Exposed *Artemisia arbuscula* ssp. *thermopola*/*Sitanion hystrix* site; highly erosive.

## GENERAL METHODS

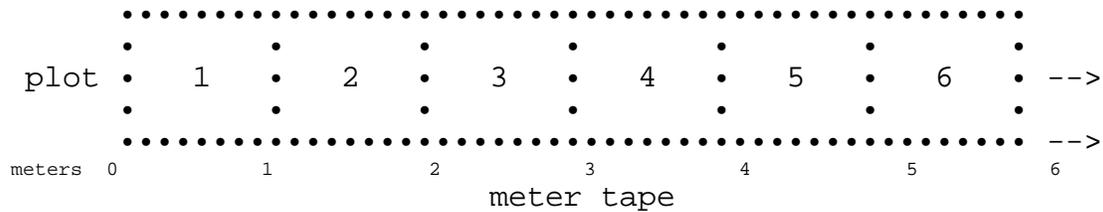
### Field Sampling

For recording of demographic data for *Draba trichocarpa* and *Eriogonum meledonum* we used methods developed by Lesica (1987). The technique employs a randomly-placed, contiguous, subdivided belt transect that has been found to be useful for nonrhizomatous perennial plants with low to moderate density.

Our choice of transect locations included only those populations or portions of populations where the act of sampling would not significantly disturb the population; *i.e.*, we did not place transects in steep, loose scree. Each transect is randomly placed within a population. The transects are of variable length, depending on population density; the object is to sample a sufficiently large number of individuals for modeling. Each transect was permanently marked by placing reinforcing bar at the start and end points. They were colorfully marked with orange paint and their location marked on maps and described in relation to conspicuous landmarks.

A transect consists of adjacent 1 m<sup>2</sup> quadrats placed along one side of a tape stretched between the start and end points (Figure 2). The tape is always the X axis. Each quadrat is graduated in 1 cm increments along the x and y axes to be used for establishing a coordinate locator for each target plant encountered. For each quadrat along the transect there is a corresponding box on the data form where the location of each plant is mapped. Coded life history data for each plant are written next to the corresponding mark on the data form in 1990 and 1991. In 1992 we decided it was quicker to have a list (as opposed to the original plot map) of all the plants from previous years along with their coordinates. A modified version of the LOTUS 1-2-3 data file (Appendix 1) was used for this with success.

Figure 2. Diagrammatic representation of the belt transect used in the Stanley Basin demographic monitoring study.



### Population Modelling

Field data was entered into LOTUS 1-2-3 files where descriptive statistics were computed (Appendix 1). These statistics, relating to the demography of the *Draba trichocarpa* and *Eriogonum meledonum* populations, were used to construct population models. Population modelling can be an effective way to use demographic information to project future population trends and to assess the effects of various management activities on population dynamics (Menges 1986). The computer program RAMAS/stage (Ferson 1991) was used to execute a type of population modelling using transition matrices. Three years of data, representing two transitions (*i.e.*, 1990 to 1991 and 1991 to 1992) are insufficient to make strong conclusions about projected population changes, but transition matrix models are generally fairly robust to small changes in the matrix components, and are therefore useful for identifying aspects of population dynamics that are crucial to population growth and decline. As additional years of data become available, the model can be updated and its usefulness as a tool in projecting population trends and predicting the effects of various management options will improve (Kaye 1992).

To construct the population model, each individual *Draba* and *Eriogonum* plant was categorized into one of three stages: seedlings, nonreproductive, and reproductive (defined for each species in later sections). Transition matrix models are so named because they are matrices of transition probabilities, that is, the rates at which one stage makes the transition to another stage. Once constructed, the transition matrix is post-multiplied by a vector representing the abundance of individuals in each stage category (Kaye 1992). This method can be used to calculate the equilibrium population growth rate ( $\lambda$ ), the rate at which a population will grow or decline. If  $\lambda$  is greater than one there is a positive growth rate indicating a demographically healthy population. Conversely, if  $\lambda$  is less than one, the population is projected to decline (Menges 1986; Kaye 1992). In RAMAS/stage,  $\lambda$  is calculated as the dominant eigenvalue.

## RESULTS

### *DRABA TRICHOCARPA*

#### Natural History and Morphology

*Draba trichocarpa* is a perennial forb emanating from a narrow taproot, with a low, compact growth form commonly referred to as a cushion plant. The caudex is profusely branched and is covered with old leaves and leaf-bases. It has small, but conspicuous, yellow flowers occurring in a scapose inflorescence that is up to three cm long. There are generally two to four fruits produced per inflorescence, although as many as five or six have been observed. One to four, plump, wingless seeds are produced per fruit.

Less than 7,000 *Draba trichocarpa* individuals are known, occurring in 14 populations and occupying less than 100 acres. Little is known of its life history characteristics. It begins growth very early in the season, before or immediately after snow-melt. In the Stanley Basin, this occurs sometime in May depending on spring temperatures. Flowering takes place soon afterward and lasts for two to three weeks. Most plants are in fruit by the end of June. Fruits mature rather quickly and seeds disperse by mid- to late June, again depending on weather (especially temperature) conditions of late spring and early summer. The plants begin to go dormant with the onset of fruit maturation, with the leaves becoming dried and tightly imbricated. Fall growth, or at least a regreening of the leaves, has been observed after the onset of fall rains in September and October.

#### Field Methods

Each *Draba trichocarpa* plant falling in a plot was assigned one of the following stage class codes:

- S Seedlings = very small plants with one rosette of leaves. Attribute recorded: presence/location.
- N Nonreproductive = plants with greater than one rosette that are not producing inflorescences. Attribute recorded: presence/location.
- R Reproductive = plants that have one or more inflorescences. Attributes recorded: (1) presence/location; (2) fecundity data as described below.

Fecundity data for reproductive plants:

- I Number of inflorescences per plant.
- F Average number of mature fruits per inflorescence.
- A Number of aborted fruits per plant (fruits that never fully developed; usually noticeably smaller and shriveled compared to others).
- P Number of inflorescences removed by predation per plant.

We also recorded the diameter of each plant by averaging of the longest and shortest dimensions of the living portion of the cushion.

## Seeds

In addition to that portion of the population readily visible in the plots, we also wanted to gain an understanding the fecundity rates and the potential contribution of the seed stage to population dynamics. The time we read the transects always coincided with the time when the draba fruits appeared mature or were beginning to dehisce. At the time of sampling, we collected approximately 50 fruits from each population in areas greater than 10 m from the transect. They were brought back to Boise and air dried at room temperature until viability testing took place.

To test for seed viability, we used the tetrazolium method (Grabe 1970) at the facilities of the USDA Forest Service, Intermountain Research Station, Forestry Sciences Laboratory in Boise. To begin with, the seeds were soaked in distilled water for 24 hours. Then the seed coat was scored (a small break in the surface) with a sharp razor blade on the cotyledon side of the embryo. In *Draba trichocarpa* the cotyledon side of the seed is the wider side; the opposite being the hypocotyl. Then the seeds were placed in a 1% tetrazolium solution in a glass petri dish, making sure that the seeds were completely immersed; no floating seeds. It takes 4-12 hours for the reaction to stain completely, although 3-4 hours seemed sufficient for our purposes. Tweezers and a dissecting needle work well together in tearing the seed coat from the embryo.

## Population Structure and Averages

Table 2 displays selected statistics relating to the population structure of *Draba trichocarpa* at the five populations measured in the Stanley Basin. Data collected at each plot, as well as some summary statistics, appear in Appendix 1. A total of 382 plants were mapped in the five transects 1992. This is similar to the 378 plants recorded in 1991, and the 375 recorded in 1990. The highest density population remained Stanley #4 (Transect 5) in 1992, although the difference between this transect and the others was not as large as in past years. The structure of all five populations is heavily skewed toward the reproductive stage, averaging 70% of the population over the three years of data. Nonreproductive individuals comprised the next largest category with 29% of the population. This stage far surpassed seedlings, which were very scarce in all transects throughout the three year period, comprising just 1% of the population.

The reproductive output declined or remained steady for four of the five transects from 1991. Middle Stanley (Transect 3) remains the population with the highest output, with an average of 94.9 seeds per reproductive plant in 1992. The fluctuations in reproductive output were due largely to fluxes in the number of inflorescences and number of fruits produced; the number of seeds produced by each fruit generally remained the same over the three year period, although it increased in Transects 5 and 6 in 1992. No predated fruits were recorded in the three years.

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Table 2. 1990 to 1992 population density and fecundity data for *Draba trichocarpa* in five long-term monitoring transects established in the Stanley Basin.

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TRANSECT #	1			3			4		
	1990	1991	1992	1990	1991	1992	1990	1991	1992
Total # plots/transect 25		25	25	25	25	25	25	25	25
Total # plants/transect 90		63	82	74	93	102	97	81	76
Density (plants/m <sup>2</sup> )	2.5	3.3	3.0	3.7	4.1	3.9	3.2	3.0	3.6
Total # seedlings/transect (% population)	0(0)	6(7)	0(0)	0(0)	1(1)	0(0)	8(10)	2(3)	5(6)
Total # nonreprod/transect 15(20) 17(19) (% population)	30(48)	18(22)	22(30)		38(41)	18(18)	21(22)		40(49)
Total # reprod/transect 59(77) 68(75) (% population)		33(52)	58(71)	52(70)		55(55)	83(81)	76(78)	33(41)
Avg # fruits/inflorescence	3.3	2.9	2.2	3.2	5.5	3.7	2.9	4.7	3.4
Total # fruits/transect 1472		633.6	1241	783	1130	5803	2886	529	1894
Avg # fruits/reprod plant	19.2	21.4	15	20.5	70	38	16	32.1	21.6
Avg # seeds/fruit	2.3	1.9	2.4	1.9	2.3	2.5	2.3	2.3	2.6
Total seeds/transect	1457	2358	1879	2146	13,347	7215	1216	4356	3974
Avg seeds/reprod plant 58.4		44.2	40.7	36.1	39.0	161	94.9	36.9	74

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 Table 2. Continued.  
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TRANSECT #	5			6		
	1990	1991	1992	1990	1991	1992
Total # plots/transect	15	7	7	25	25	25
Total # plants/transect	110	34	28	68	84	93
Density (plants/m <sup>2</sup> )	7.3	4.9	4.0	2.7	3.4	3.7
Total # seedlings/transect (% population)	0(0)	0(0)	0(0)	3(5)	2(2)	1(1)
Total # nonreprod/transect (% population)	70(64)	2(6)	5(18)	18(26)	18(22)	23(25)
Total # reprod/transect (% population)	40(36)	32(94)	23(88)	47(69)	64(76)	69(74)
Avg # fruits/inflorescence	3.0	5.4	3.2	4.1	4.6	3.7
Total # fruits/transect	588	1444	803	1476	2737	2116
Avg # fruits/reprod plant	14.7	45.1	34.9	31.4	42.8	30.6
Avg # seeds/fruit	1.1	1.1	2.0	1.6	1.6	2.5
Total seeds/transect	646.8	1588	1606	2362	4379	5290
Avg seeds/reprod plant	16.2	49.6	69.8	50.2	68.4	76.7

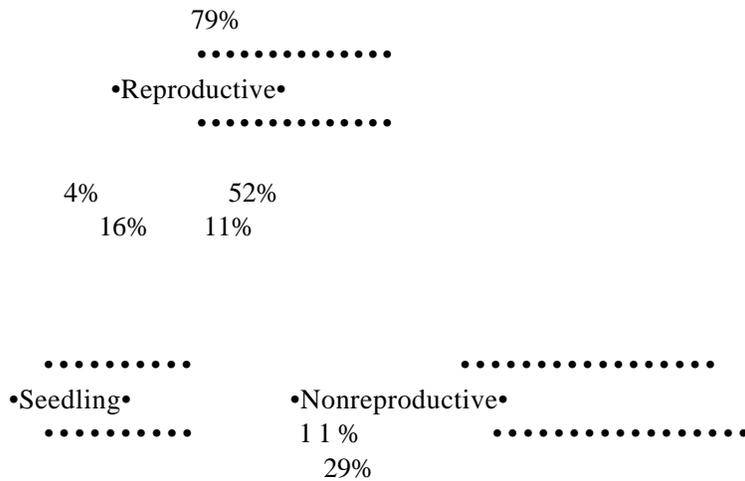
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Population Model

Matrix projections begin with the stage structure (*i.e.*, seedling, nonreproductive, reproductive) of the *Draba trichocarpa* populations in 1990. The stage structure then changes over one year as some individuals remain at that stage, while others grow to another stage or die. We collected data on two transitions, which were used in the model to calculate stage-specific survivorships, fecundity, and transfer (growth) rates in order to project (model) the future dynamics of the population.

For *Draba trichocarpa*, we first constructed a diagram of the life history of the species (Figure 3). Arrows in Figure 3 represent transfers that take place between stages each year. These transfer rates were calculated from the 1990 through 1992 monitoring data (see Appendix 2 for life stage transition data for the six transects). We calculated the reproductive to seedling transition by dividing the number of 1990 and 1991 reproductive plants by the number of 1991 and 1992 seedlings. Due to the limited scope of this study, we had to assume that there is no seed dormancy and the seed predation was zero.

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 Figure 3. The life cycle of *Draba trichocarpa*. Reproductive output and transfer rates were calculated using 1990 to 1992 data.  
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We next prepared a projection matrix (Figure 4) corresponding to the life cycle presented in Figure 3. Each number in the matrix represents a transfer from the column stage to the row stage. For example, in one year, 29% of nonreproductive individuals remain nonreproductive (column 2, row 2), while 52% become reproductive (column 2, row 3). The average number of viable seeds per reproductive plant appears in column 3, row 1.

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 Figure 4. Projection matrix corresponding to the life cycle of *Draba trichocarpa* presented in Figure 3.  
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		FROM:		
		Seedling	Nonreproductive	Reproductive
	Seedling	0.0	0.0	0.043
TO:	Nonreproductive	0.11	0.29	0.11
	Reproductive	0.16	0.52	0.79

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 The matrix model, as executed by RAMAS/stage, projects that *Draba trichocarpa* is expected to decline at the five populations sampled if environmental conditions remain constant. The equilibrium growth rate ( $\lambda$ ) of the populations was calculated to be 0.89666493, indicating that the populations will decrease in size. Figure 5 shows the population decline over the next five years as projected by the model.

Much of the reason for this decline can be attributed to the very low recruitment of seedlings into the population. We recorded a seedling mortality rate of 73% in our three years of measurement. At this rate, it appears that there is not enough seedling recruitment to match the mortality rate of the other two stages. In other words, our data suggest that the species is not stable.

There are two possibilities to explain this predicted species decline. One is that the decline is real and that the low seedling survival jeopardizes the long-term viability of the species. The other is that our data are insufficient. Because seedling survival is more sensitive to environmental fluxes, such as spring rainfall, than survival of the other stages, longer-term measurements may be needed to fully understand this aspect of *Draba trichocarpa* population dynamics. A relatively long-lived perennial, such as *Draba trichocarpa*, probably needs a "good" seedling establishment year infrequently to maintain population viability. Our three years of measurements may not have coincided with a "good" year.

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Figure 5. Projected decline of *Draba trichocarpa* at five populations over a five year interval. Population size includes the total number of plants in the five populations, including seedlings, nonreproductive, and reproductive.

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## ***ERIOGONUM MELEDONUM***

### Natural History and Morphology

*Eriogonum meledonum* is a low, perennial subshrub forming mats four to twelve inches across. The leaves are basal, spatulate to narrowly elliptic, and covered with a densely grayish tomentum on both surfaces. The flowering stems are scapose, up to six inches tall and topped by a dense, capitate inflorescence of bright yellow flowers, each potentially producing a three-angled achene. It reproduces entirely by sexual methods, but occasionally the branching caudex spreads out enough, and is covered by soil, to make it appear that there are two individuals. We do not know if this branch actually separates and creates a "new" individual.

Only ten populations of *Eriogonum meledonum* are known, containing an estimated 4,500 individuals and occupying less than 45 acres. As with *Draba trichocarpa*, little is known of its life history characteristics. It begins growth early in the season, very soon after the snow melts in May. Flowering is somewhat delayed, as compared with the draba, anthesis usually peaking in late June, but varying greatly depending on spring temperatures. When fruits mature the entire flower, including the dried perianth, disperses as a unit.

### Field Methods

Each *Eriogonum meledonum* plant falling in a plot was assigned one of the following stage class codes:

- S      Seedlings = plants that lack woody tissue. Attribute recorded: presence/location.
- N      Nonreproductive = plants with woody stems that are not producing inflorescences. Attribute recorded: presence/location.
- R      Reproductive = plants that have one or more inflorescences. Attributes recorded: (1) presence/location; (2) fecundity data as described below.

Fecundity data for reproductive plants:

- I      Indicates the number of inflorescences per plant.
- A      Indicates the number of aborted inflorescences per plant (flowers with no apparent fruit formation).
- P      Indicates the number of inflorescences removed by predation per plant.

We also measured the diameter of each plant by averaging of the longest and shortest dimensions of the living portion of the cushion, in centimeters. Because it would have been too time consuming to count flowers on each inflorescence, we sampled plants in the population (greater than 10 m from the transect) to get an average number of flowers per inflorescence. Twenty inflorescences were sampled per site by this technique. These inflorescence samples were also used for seed production estimates (described in the next section).

## Seeds

As with *Draba trichocarpa* we wanted to determine seed production and viability. Phenology of *Eriogonum meledonum* at the time we read the transects ranged from peak anthesis to early dispersal. In 1990, fruits were not mature at the time of sampling. Upon a return trip to collect mature achenes it was difficult to find intact inflorescences with fruits that had not dispersed. Kaye *et al.* (1990) found a similar situation in two closely-related species of *Eriogonum* in Oregon. They found that fruits rapidly break free from the inflorescence with the perianth attached, allowing for rapid dispersal. This may account for the wide variability in fruit and seed production estimates from our 1990 samples (Table 3).

In 1991 and 1992, when the flowers appeared to be at the early dispersal stage, as indicated by dried perianth parts, we bagged the inflorescence with fine netting to prohibit the loss of dispersing achenes. Flowers at the outside of the inflorescence reach anthesis before those on the inside. Due to this differential maturation rate, the netting may have inhibited pollinators from the late-maturing flowers. We tried to minimize this in our sampling. If the inflorescences were at anthesis and not beginning to disperse at the time we read the transect, we came back to the study area a short time later, usually within a week or two, and bagged the inflorescences then. We then came back a third time later in the summer after full maturity to collect the samples. The samples were brought back to Boise and stored at room temperature until viability testing took place. From the sample of twenty bagged inflorescences per site, we sampled 50 fruits for an estimate of aborted fruits and seed viability.

To test for seed viability, we used the tetrazolium method at Intermountain Research Station Forestry Sciences Laboratory. To begin with, the seeds were soaked in distilled water for 24 hours. The perianth parts were then removed from the achene. Then the fruit coat was scored (a small break in the surface) with a sharp razor blade and the seeds were placed in a 1% tetrazolium solution in a glass petri dish, making sure that the seeds were completely immersed. It takes 4-12 hours for the reaction to stain completely. Tweezers and a dissecting needle work well together in tearing the seed coat from the embryo.

## Population Structure and Averages

Table 3 displays selected statistics relating to the population structure of *Eriogonum meledonum* at the four populations measured in the Stanley Basin. Data collected at each plot, as well as some summary statistics, appear in Appendix 1. *Eriogonum meledonum* density remained remarkably constant through the three year study period. Because only four seedlings in one transect (Transect 1) were recorded during the study, it was the nonreproductive and reproductive stages that collectively contributed to this stability. A possible scenario that may explain this population attribute is that while seedling establishment and survival is very rare, the ones that do survive become long-lived individuals. There was however, considerable fluctuations in the nonreproductive and reproductive stages. Many plants that were recorded as reproductive one year did not produce flowers the next and, therefore, "reverted" to the nonreproductive stage. Between 1990 and 1991, the number of reproductive plants dropped dramatically, which in turn affected the overall fecundity.

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 Table 3. 1990 to 1992 population density and fecundity data for *Eriogonum meledonum* in five long-term monitoring transects established in the Stanley Basin.  
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TRANSECT #	1			2		
	1990	1991	1992	1990	1991	1992
Total # plots/transect	25	25	25	50	50	50
Total # plants/transect	55	56	56	129	126	125
Density (plants/m <sup>2</sup> )	2.2	2.2	2.2	2.6	2.5	2.5
Total # seedlings/transect (% population)	0(0)	4(7)	0(0)	0(0)	0(0)	0(0)
Total # nonreprod/transect (% population)	33(60)	31(55)	32(57)	61(47)	93(74)	103(82)
Total # reprod/transect (% population)	22(40)	21(38)	24(43)	68(53)	33(26)	22(18)
Avg # achenes/inflorescence	20.9	5.5	13.2	18.0	29.2	23.6
Total # achenes/transect	4617	787	2033	5796	3154	4484
Avg # achenes/reprod plant	210.0	95.6	84.7	85.2	95.6	203.8
% seed (achene) viability	0.0	0.0	2	41	28	13
Avg viable seeds/reprod plant	0.0	0.0	1.7	34.9	26.8	26.5

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 Table 3. Continued.  
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TRANSECT #	5			6		
	1990	1991	1992	1990	1991	1992
Total # plots/transect	15	15	14	25	25	25
Total # plants/transect	62	71	60	42	42	45
Density (plants/m <sup>2</sup> )	4.1	4.7	4.3	1.7	1.7	1.8
Total # seedlings/transect (% population)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)
Total # nonreprod/transect (% population)	38(61)	57(80)	57(95)	11(26)	27(64)	17(38)
Total # reprod/transect (% population)	24(39)	14(20)	3(5)	31(74)	15(36)	28(62)
Avg # achenes/inflorescence	30.1	11.5	20.8	44.8	24.6	34.7
Total # achenes/transect	1535	276	125	10,348	1649	2336
Avg # achenes/reprod plant	63.9	19.7	41.6	333.8	110	83.4
% seed (achene) viability	8	14	13	49	10	25
Avg viable seeds/reprod plant	5.1	2.8	5.4	163.6	11	20.9

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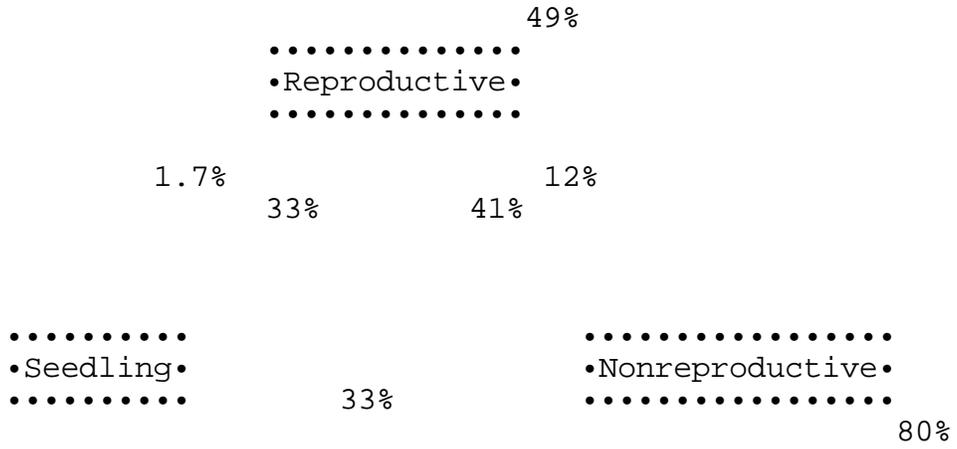
### Population Model

For *Eriogonum meledonum* matrix projections begin with the stage structure (*i.e.*, seedling, nonreproductive, reproductive) of the population in 1990. The stage structure then changes over one year as some individuals remain at that stage, while others grow to another stage or die. We collected data on two transitions, which were used in the model to calculate stage-specific survivorships, fecundity, and transfer (growth) rates in order to project (model) the future dynamics of the population.

As we did with *Draba trichocarpa*, we first constructed a diagram of the life history for *Eriogonum meledonum* (Figure 6). Arrows in Figure 6 represent transfers that take place between stages each year. These transfer rates were calculated from the 1990 through 1992 monitoring data (see Appendix 3 for life stage transition data for the six transects). We calculated the reproductive to seedling transition by dividing the number of 1990 and 1991 reproductive plants by the number of 1991 and 1992 seedlings. Due to the limited scope of this study, we had to assume that there is no seed dormancy and the seed

predation was zero. We next prepared a projection matrix (Figure 7) corresponding to the life cycle presented in Figure 6.

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 Figure 6. The life cycle of *Eriogonum meledonum*. Reproductive output and transfer rates were calculated using 1990 to 1992 data.  
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 Figure 7. Projection matrix corresponding to the life cycle of *Eriogonum meledonum* presented in Figure 6.  
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		FROM:		
		Seedling	Nonreproductive	Reproductive
	Seedling	0.0	0.0	0.017
TO:	Nonreproductive	0.33	0.80	0.41
	Reproductive	0.33	0.12	0.49

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The matrix model projects that *Eriogonum meledonum* is expected to decline at the four populations sampled if environmental conditions remain constant. The equilibrium growth rate ( $\lambda$ ) of the populations was calculated to be 0.91836362, indicating that the populations will decrease in size. Figure 8 shows the population decline over the next five years as projected by the model.

As in the population model for *Draba trichocarpa*, the nonreproductive and reproductive stages are relatively stable, with low mortality. The seedling stage is the weakest part of the model, and has been mentioned previously, our knowledge of the biological parameters associated with the reproductive - seedling transition is woefully inadequate. We recorded only four *Eriogonum meledonum* seedlings in our plots for the three year study period, a very low sample size from which to calculate transition probabilities. The population decline expressed by the model suggests that the species is not stable and that the extremely low seedling recruitment may not match the mortality rate of the other two stages.

The two scenarios used to explain the predicted decline of *Draba trichocarpa* are also applicable here: (1) low seedling survival jeopardizes long-term viability and (2) three years of data collection is insufficient to calculate realistic transition probabilities from the reproductive to the seedling stage.

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Figure 8. Projected decline of *Eriogonum meledonum* at five populations over a five year interval. Population size includes the total number of plants in the five populations, including seedlings, nonreproductive, and reproductive.

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## CONCLUSIONS AND RECOMMENDATIONS

1. It became clear during the second year of sampling (1991) that a small difference in tape position will create problems in exactly lining up the plots to map individual plants at their same coordinates as 1990. For modeling purposes, it is important that we are able to track each individual over the years and record demographic data for each of those plants. When establishing the transects in 1990, we permanently marked the start and end of each transect. It became apparent that this was not enough and intermediate markers were placed at intervals in several transects. The intermediate markers were 3-inch masonry nails, painted red, with silver washers that were flush to the surface. In retrospect, longer spikes should be used in areas where bedrock is not close to the surface; the longer spike would move less in the unstable scree. We recommend that this be done the next time the transects are read.

Also, several stakes used to mark the beginning and end of the transects were dislodged between sampling. In 1992, we more solidly placed transect markers. These monuments should be checked periodically and firmed up as needed to assure permanence.

To decrease our reliance on monuments to mark the beginning and ending of each permanent transect, latitude and longitude or UTM coordinates should be recorded using the Global Positioning System (GPS). If time allows, we will try and get the GPS readings for each transect in 1993.

2. Our data and model are biased to that part of populations occurring on stable habitats. *Draba trichocarpa* and *Eriogonum meledonum* occur on both gentle ridgeline habitats that are relatively stable and on steep rock outcrops and in scree. We placed all six transects on the former topographic position, because we felt that the sampler damage on the unstable habitats was unacceptable.

3. While the method of mapping individual plants along a transect employed in this study works well with low- to medium-density populations, it does not work well with high-density populations. We found that the X, Y coordinate system in the 1 m<sup>2</sup> plot is not accurate enough to locate and return to individual *Eriogonum meledonum* and *Draba trichocarpa* plants when they occur in dense patches. A combination of several factors, including relatively small size of the plant, irregular ground surface, and the sampling frame, give an accuracy of one to two centimeters for locating a plant in the plot. Such is the case with the first eight plots of Transect 5 (Stanley #4), where the population density of *D. trichocarpa* was so high, that in 1991 it was impossible to precisely determine the location of individuals mapped in 1990 (*E. meledonum*, however, was of sufficiently low density along this transect that we could map it properly). Because of this lack of precision, we determined that the first eight plots along this transect were unusable for population modeling. We also had difficulty reading parts of other transects for the same reason.

4. Demographic studies of rare plants can be fraught with difficulties (Harvey 1985; Owen and Rosentreter 1992) and some species may not even be amenable to sampling for demographic parameters necessary for modelling (Larkin and Salzar 1992). We found, however, that the habit, habitat, and life history of *Draba trichocarpa* and *Eriogonum meledonum* are suitable for development of stage-structured matrix models. Generally, a minimum of three years of data, representing two transitions, are needed to make predictions on future population trends using matrix models. A decade or more of data, however, will appreciably increase the power of the model by including relatively long-term annual variability. A

much longer-term data set is needed for the Stanley Basin endemics. Our model was constructed using only four *E. meledonum* and 19 *D. trichocarpa* seedlings. This is the life stage most prone to annual climatic fluctuations, and more years of data would greatly enhance our predictive ability. We believe that it is this low number of seedlings, combined with low survival rates, that is responsible for the species decline predicted by our models.

5. Because of funding constraints, our models for *Draba trichocarpa* and *Eriogonum meledonum* were constructed with only the three stages for which we could easily collect data: seedling, nonreproductive, and reproductive. The fourth and important stage is the seed. Unfortunately, the contribution of this stage to the model was indirectly inferred, rather empirically derived.

Instead of simply using seedling survival data, as we did, seed survival, seed germination, in addition to seedling survival should be used. Another major inadequacy is the lack of knowledge concerning the seed banking ability of either species. We had to assume that seed dormancy did not last longer than one year, which is a major leap of faith. Seed predation rates are also unknown.

6. Two major data gaps need to be filled before future population fluctuations, and risk of extinction or decline can be more accurately modelled:

(a) a longer-term data set is needed to encompass a greater amount of annual variability; and

(b) a seed stage, based on direct observation instead of inference, needs to be built into the model. Demographic monitoring should continue, however, even if a seed stage is not added.

While demographic monitoring has proven very useful in rare plant management (Sutter 1986), emphasis must continually be placed on protection and maintenance of the natural habitats where the species live. In fact, demographic attributes, such as the fitness of an individual, may be influenced more by the ecological quality of the habitat for seedling germination and establishment than by total reproductive output (Owen and Rosentreter 1992). Luckily, the human disturbances taking place at the populations of *Draba trichocarpa* and *Eriogonum meledonum* in the Stanley Basin are relatively minor and manageable. The Sawtooth National Forest should continue to frequently monitor the demographic attributes of the populations and each decade monitor vegetation trends, as well as assure the long-term protection of all the populations of these rare species.

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Appendix 1.

1992 Lotus 1-2-3 data files for the six Stanley Basin transects.  
(see Moseley and Mancuso (1990; 1992) for 1990 and 1991 data.)

Appendix 2.

Life stage transition data, 1990 to 1992, for *Draba trichocarpa*.

Appendix 3

Life stage transition data, 1990 to 1992, for *Eriogonum meledonum*.